SOLAR RESEARCH NOTES

AN ATTEMPT TO PHOTOGRAPH PROMINENCES
IN THE INFRARED LINE OF HELIUM λ 10830

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In the article is given a description of an attempt to photograph prominences in the infrared line of helium λ 10830 both by means of a spectrograph and by means of an interference-polarization filter. I give preliminary results of a comparison of emission of prominences in line λ 10830 with emission in lines of helium D_3 and Hα of hydrogen.

The first direct photographs of the sun in λ 10830 were obtained by d'Azambuja [1, 2] on sensitized plates using a spectroheliograph, and by A. B Severny on phosphorus through the interference-polarization filter [3] at the Crimean Astrophysical Observatory. Although d'Azambuja obtained photographs of the solar disk only, A. B Severny obtained pictures of prominences. At the present time this observatory is doing simultaneous photography in λ 10830 both of prominences directly through the narrow-band interference-polarization filter and of their spectra on the spectrohelioscope-spectrograph [4]. Photography of emission spectra of prominences in the infrared line of helium λ 10830 is carried out by means of an image converter with 8 A/mm dispersion In Fig 1 are given pictures of the infrared spectra of the sun, with indication of the wavelengths. In the first picture there are visible dark Fraunhofer lines, in the second -- a light inversion of the prominence in line λ 10830, and in the third picture is given a spectrum of the chromosphere with intense emission in this same helium line

Due to the favorable combination of instruments on the spectrohelioscope, line λ 10830 falls on the photo-cathode of the image converter just when we can observe Hα in the spectrum of the second order at the center of the spectrohelioscope's field Hence in photographing spectra of a prominence we can guide it by means of the inversion of Hα in the spectra in the second order In order to remove the yellow-green portion of the spectra in the second order, which falls on the photo-cathode, we have installed a glass filter in front of it (Other lines of emission in the prominence, such as Hα, Hβ, D_3, H and K, were photographed simultaneously with λ10830.) Agfa Yellow Rapid plates were used to photograph through the image converter An exposure of around 15 sec. was found to be sufficient for these plates, i.e , this was equal to the exposure time for other lines of the spectrum

Preliminary measurements of a series of spectrograms give equivalent widths of 0.02-0.03 A for emission of λ 10830 in the prominence These values

are only 2-3 times less than the estimates carried out in 1950 by A. B. Severny [3] in photography in phosporus using the interference-polarization filter. In order to reduce the spectrograms, aureole and scattered light in the instrument were taken into account. The total value of the scattered light was $1 \cdot 10^{-3} - 8 \cdot 10^{-3}$. The amount of the aureole in the yellow portion of the spectrum was $0.5 \cdot 10^{-2} - 1 \cdot 10^{-2}$.

The image converter gives a rather strong background (around $3 \cdot 10^{-2}$), which, in addition, is distributed on the plates in a highly irregular fashion. Calculation of this background presents notorious difficulties and considerably reduces the accuracy of the results.

A new method permitted us to obtain a sufficient number of spectra to make preliminary comparisons of emission of prominences in λ 10830 and in hydrogen Hα and helium D_3. In Fig. 2 are given preliminary results of such a comparison. Along the horizontal axis is given the total emission of Hα in the prominence, in units of intensity of a strip 1 A wide in the continuous spectrum of the center of the solar disk at this same wavelength. Along the vertical axis are given the same values for helium λ 10830 (curve A) and for helium D_3 (curve B). The run of change in intensity of emission in D_3 with increase in emission intensity in Hα, in general, agrees with the results of Brucka and Moss [5]. It is characteristic that the growth of intensity in λ 10830 with increase in emission intensity in Hα is less than the growth of intensity in D_3.

Simultaneously with photography of the spectrum, we did direct photography of prominences through the interference-polarization filter. Photography was carried out on an instrument of the outside-of-eclipse type coronagraph of Lyot. This instrument was used earlier for observation of prominences in Hα, and its description is given in [6]. In order to isolate a narrow pass-band we used an infrared interference-polarization filter, designed and constructed by Gilbarg and Severny (see [3]). The filter was provided with supplementary parts made up of two quartz plates, which, in combination with the regular interference filter, allowed us to select one single pass-band, centered on λ 10830, from among a large quantity of pass-bands on the interference-polarization filter. The half-width of the selected pass-band was around 12 A. As we know, the location, in the spectrum, of the filter's pass-band and its width depend strongly on the filter's temperature and its inclination with respect to incident light. The visibility of prominences in the coronagraph is highly sensitive to other factors, so that the filter requires careful and precise installation. Visibility of prominences is also found to be highly sensitive to the focussing and adjusting of the coronagraph. But with good focussing and mounting of the coronagraph we can visually observe prominences on the converter screen with sufficient distinctness. Thus visibility of prominences is considerably better than it is with observation on

the spectro-helioscope in helium D_3, in spite of the fact that on a spectro-helioscope with a dispersion of around 4 A/mm it is actually possible to distinguish one line of D_3 in the spectrum. At the same time, with the relatively wide pass-band of the filter (12 A) in λ 10830 we can see practically all of the prominence observed on the spectro-helioscope in Hα. This is explained, first of all, by the considerably less intense aureole in λ 10830 by comparison with the aureole in λ 5876. (If, in λ 10830, the equivalent width of the prominence is 5-10 times greater than the aureole, in line D_3 the equivalent width of the prominence is equal to or less than the intensity of the aureole.)

Our measurements, in general, confirm the conclusions of A. B. Severny [3] on the approximate correctness of Rayleigh's law for atmospheric scatter in the infrared region. Finally, from a comparison of theoretical intensities of transitions D-P and P-S

$$\frac{E_{DP}}{E_{PS}} = \frac{\nu_{DP}}{\nu_{PS}} \frac{A_{DP}}{A_{PS}} \frac{1}{2} \frac{g_D}{g_P} \cdot e^{-\frac{h\nu_{DP}}{kT}}$$

We would expect that where $T \approx 5000°$ K the emission in λ 10830 will be at least 10 times greater than in λ 5876.

In Fig. 3 are presented photographs of prominences in λ 10830. They were obtained through the image converter on Agfa Yellow Rapid plates with exposures from 5 to 10 sec. On the photograph of the prominence of 6/X 1951 structure is clearly visible which is absent in observations in line D_3 on the spectro-helioscope. However we should point out that the image quality on our pictures is far inferior to the quality of the prominence pictures in Hα, obtained at our observatory. This is explained, first, by the fact that there is considerable instrumental scattered light in the optical instrument that we use; second, the converter gives large grain, which considerably reduces the resolving power; third, photographic exposures are still rather long, so that during the exposure there is image vibration due to atmospheric turbulence and inadequacies of the timing mechanism of the main coelostat. Overcoming these difficulties will undoubtedly further improve the image quality.

However, in spite of these deficiencies, the photographs that we obtained allow us to draw some preliminary conclusions. A comparison of the form of prominences in λ 10830 with their form in Hα indicates that the structure of emission of prominences in λ 10830 is basically the same as the structure of emission in hydrogen lines. But along with this there are observed discrepancies in structure. In particular, on the pair of photographs of the same

prominence of 27/IX 1951* in both λ 10830 and Hα, given for comparison, it is obvious that the prominence is higher in λ 10830 than in Hα Waldmeier [7] pointed out a similar discrepancy in structure of helium and hydrogen emission in prominences.

I express my sincere thanks to Prof A. B. Severny for guidance in my work.

*Translator's note Text says 27/IX 1951, but this must be a misprint. The pictures dated 28/IX 1951 are the only two that fit the text

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Fig 1 and another unnumbered Fig. are photographs and cannot be copied satisfactorily.

Caption

Fig 1 Infrared spectra of the sun

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Reproductions of original diagrams: Peggy Smith
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